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E-learning study materials focused on projects from industry

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Abstract

Theoretical knowledge and theoretically oriented study materials are always great advantage of education at universities. However, access to learning materials and know-how used in industrial practice is very limited. With regard to this issue the Faculty of Mechanical Engineering at the University of West Bohemia has launched a project in which example projects from practice are worked on. The outputs of each of the projects are e-learning pdf files. These study materials contain all important information which the designer normally comes into contact with in practice. There are tender dossiers, interactive 3D models, drawings, processes (welding, machining, assembly...). One of these projects is focused on a curing press, which will be used for a closer examination of the developed study materials.

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Keywords: e-learning; study materials; machine design; design projects; CAD models; 3D models

1. Introduction

Industrial companies have high demands on graduates of the Department of Machine Design, Faculty of Mechanical Engineering at the University of West Bohemia. These requirements could be divided into theoretical and practical knowledge. Theoretical knowledge and theoretically oriented study materials are always great privilege of education at universities. However, the accessibility of learning materials and know-how which are used in industrial practice are very limited. Another problem is the lack of practice and the offer of internships from industrial companies for students in technical fields which would balance the lack of these materials to a certain degree.

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With regard to this issue Faculty of Mechanical Engineering has launched a project where the example projects from practice are processed. The individual projects are worked out by academics with the support of industrial companies. The output of each project is an e-learning pdf file. These e-learning study materials are comprehensive instructions for designers containing a tender dossier, interactive 3D models, drawings and processes (welding, machining, assembly etc.). One of these projects is focused on a curing press, which is supposed to be used as the example of the developed study materials.

Currently, the interest in studying technical branches is declining in the Czech Republic. According to the demographic distribution as presented in (Koucky and Bartusek, 2011) the number of university students is currently on its local maximum and for the future a decrease in number of students is expected. Although the overall number of university students is at its maximum the number of engineering students is decreasing. This applies not only for the Czech Republic, but also for the whole Europe. Only 15% of students would like to study technical and scientific fields. In Asia the phenomenon is reversed and up to 60 % of students there are interested in studying technical and scientific fields. By improving the quality of learning materials and applying modern teaching methods the attractiveness of these branches is believed to be increased to attract more students.

Various types of machines (such as hydraulic presses, manipulators of pipes, conveyors, lathes, milling machines, castings, molds, etc.) are processed within the whole developmental project. Each of these "branches" has its own specific features. These characteristics define the method of how the design documentation, technology etc. are carried out. This diversity allows students to recognize the differences between each branch. The overall concept of basic study materials is the same for all the projects. The study materials are different only according to the specifications of a processed branch of production.

2. Introduction to curing presses

Curing presses are machines where the final stage of production of tires takes place. Semi finished tires are inserted into the mold of the curing press and by treatment with a defined pressure and temperature they obtain their final shape and final mechanical properties. Nowadays curing presses are operated by a powerful control system, which ensures continuous operation and control of machine operation. Vulcanization is a chemical reaction taking place under high pressure and temperature while the vulcanizing agent changes the structure of the rubber composition.

Why a curing press? Curing presses have a long tradition of production in the Czech Republic and there are several manufacturers that export their machines all over the world. The tradition of engineering in the Western Bohemia, where the Faculty of Mechanical Engineering is situated, dates back to the beginnings of the development of Skoda factory. Emil Skoda who became the chief engineer at Waldstein Engineering in Pilsen in 1866 was responsible for the development of the Skoda factory. Three years later, he bought the company and soon changed the small factory with 33 employees into a great worldwide known company with 4000 workers and 200 engineers. He built gradually a new foundry, machinery, steel mill, blacksmith shop, railway track and an arms factory (Broz, 2004). Tire curing presses have been producing here since 1960.

Curing presses are classified as moderate weight machines in the range from 40 to 150 tons, depending on their size and design. Mostly they are produced individually or in small batches. One of the reasons why the curing press is used for these study materials is that this machine uses a wide range of components and principles commonly applied in other machines. This offers universality in the use of these study materials.

3. Requirements for the study materials

The developed study materials have to comply with commonly used standards used in the world. These criteria are intended to ensure the quality of the materials. They are also used to support the systematic effort to improve the quality of engineering education. These criteria meet the requirements in dynamic competitive environment of industrial companies.

These requirements are defined according to the Accreditation Board for Engineering and Technology (ABET, 2011). The requirements are similarly defined by the European Network for Accreditation of Engineering Education, which can be identified in (ENAE, 2008).

Requirements according to ABET (ABET, 2011):

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments, as well as to analyze and interpret data
- an ability to design a system, component, or process to meet desired needs within realistic
- constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multidisciplinary teams
- an ability to identify, formulate, and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- a recognition of the need for, and an ability to engage in life-long learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Leading experts of the Faculty of Mechanical Engineering at the University of West Bohemia, who have sufficient experience in teaching and practice in engineering, have defined additional requirements that complement or concretize the requirements defined for mechanical engineers. These requirements were published in (Hynek et al., 2013) and are as follows:

- an ability to use CAD software
- a knowledge of the mechanical design process
- a knowledge of manufacturing processes
- a knowledge of economic aspects of production
- experience with real applications
- an ability to express their thoughts unequivocally
- an ability to communicate in foreign languages
- technical creativity
- an ability to analyse and formulate technical problems
- a knowledge of total quality management principles

4. Study materials

The entire project of the curing press is divided into several parts. This division is shown in Figure 1. Each of these sections is a separate PDF file which contains the information relevant for the block. These study materials are available in PDF format which allows the use of these study materials at ordinary desktop computers as well as nowadays widespread tablets or smart phones. This eliminates the need for students to purchase student licenses for some of the CAD systems only to view 3D models.

Introductory information - Students get familiar with the basic information in this PDF file and are introduced to the problematic of curing presses. The basic functional principles of conventional curing presses are also clearly illustrated there. Students will also learn how to use all the functions of individual PDF files in this section.

Tender dossier - Tender dossier is a document which specifies customer requirements for the current bought machine. There are all technical specifications and performances. There is also a timetable and procedure for installation. The designer uses this document to create the design of the curing press.

The documentation for welding and system of validation - Welding technology is, along with the machining technology, the most common method of production of individual parts of tire curing presses. Students are introduced to the basic operations of welding in this document. The required documents for the welding process are listed there as well. The information in this PDF file is therefore generally applicable for the welding technology. The specific information about the process of welding of individual assemblies is mentioned in the PDF file which deals with the design of assemblies.

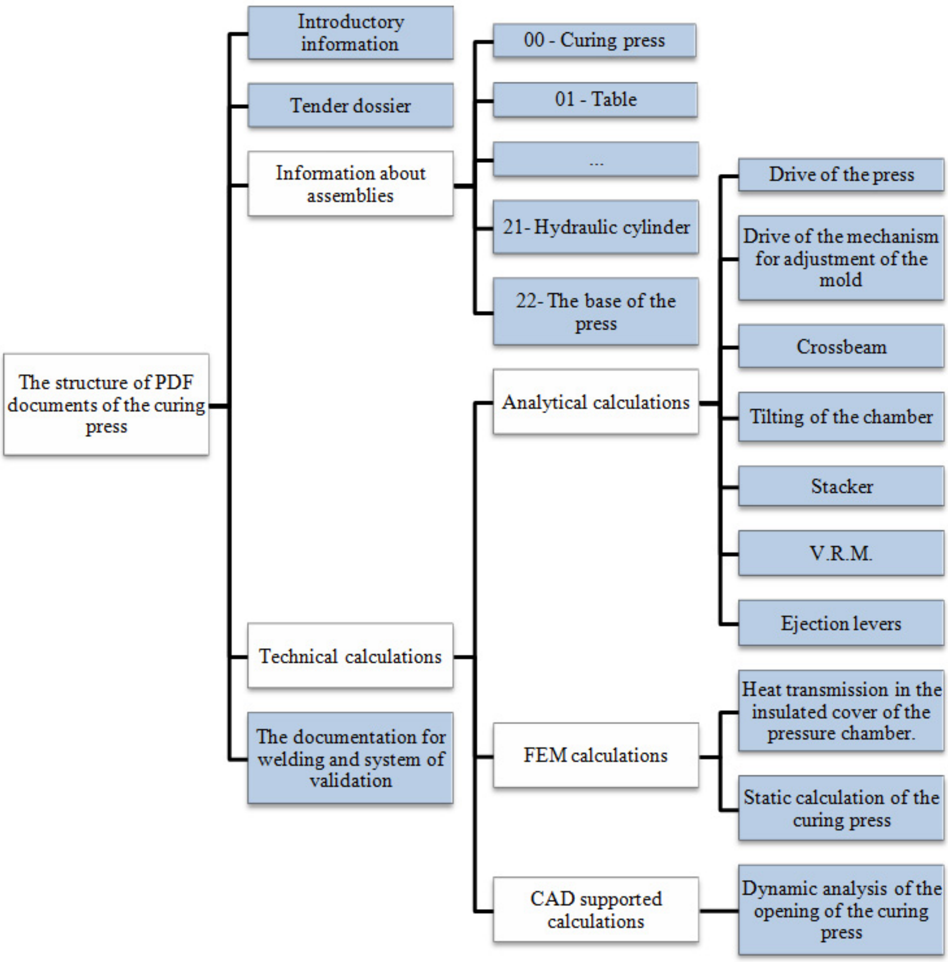


Fig. 1. Structure of PDF files of the curing press

Information about assemblies - This type of document has its fixed structure which is the same in the entire project (For example, in the lathe project, these documents look the same so students who learned to work with these documents can easily orient themselves in another machine or device project). There are all main assemblies of the curing press described in this document. There are explanations of features of specific parts and components and they are also identified and described. For example, see Fig. 2. Thanks to the technology of 3D PDF files there are 3D models which students can manipulate, rotate, hide, etc. For example, see Fig. 3.

Two colourings of components are used for the project of the curing press. The first colouring corresponds to the individual assemblies which allow students to orient themselves in the large number of parts. The second colouring has the technological nature where each part is coloured according to the machining technology. For example, see Fig. 4.

Another important part of the study materials is the complete drawing documentation. The drawing documentation contains all information necessary for the production of components such as dimensions, geometry, tolerances, surface treatment, welding, weight, information about assembling, parts list, etc. For example, see Fig. 5. The creation of drawing documentation is nowadays still the essential activity of designers and because its quality it is necessary to pay significant attention in this field. There are enclosed data sheets of purchased items in the final part of these study materials.

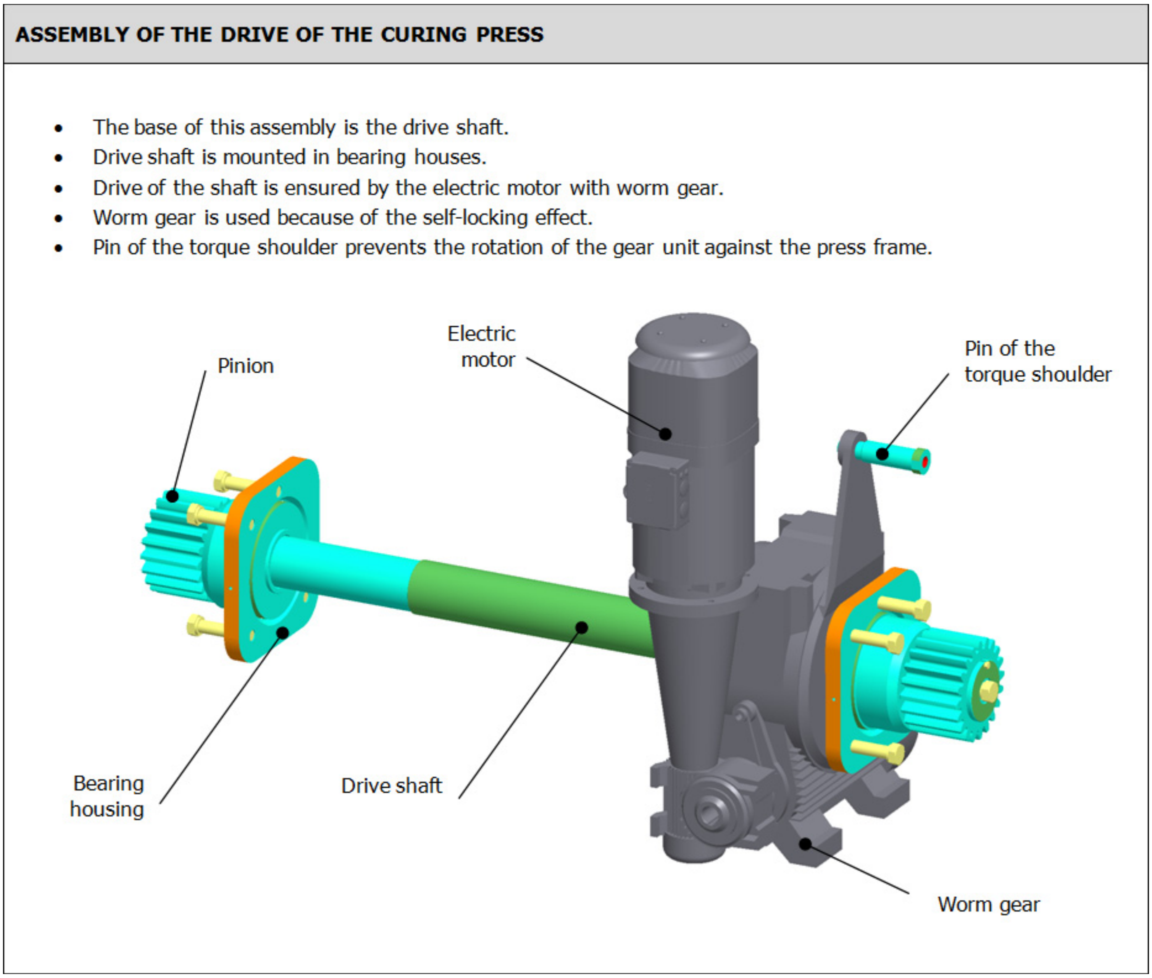


Fig. 2. Structured PDF - Description of the components of assemblies

Analytical calculations - These computational reports describe the design and check calculations of the individual components of the press. Especially there are the calculations of strength, toughness, lifetime, etc. These computational PDFs give students the overview of where and how to apply the theoretical knowledge acquired in subjects such as Mechanics or Mechanics of Deformable Solids.

FEM calculations - Advanced analysis has been done by using computer calculations with the final number of elements. These calculations include the calculation of the components whose analytical expression would be too complicated, inaccurate or impossible. There are two FEM calculations: the first calculation is the static calculation of the entire curing press and the second one is the calculation of the heat transmission in the insulated cover of the pressure chamber. For example, see Fig. 6. The temperature calculation of the insulated cover of the pressure chamber was not solved the same way as the calculations according to (Hynek and Votapek, 2013) which used the boundary layers in the heat transfer to the surrounding environment. This time only one heat transfer coefficient was specified which is more common in practice and it is easier to set the calculation.

CAD supported calculations – The calculation of the reactions in individual components of the curing press during the phase while the curing press was being opened was done by performing dynamic analysis. This analysis has been processed into a comprehensive calculation report.

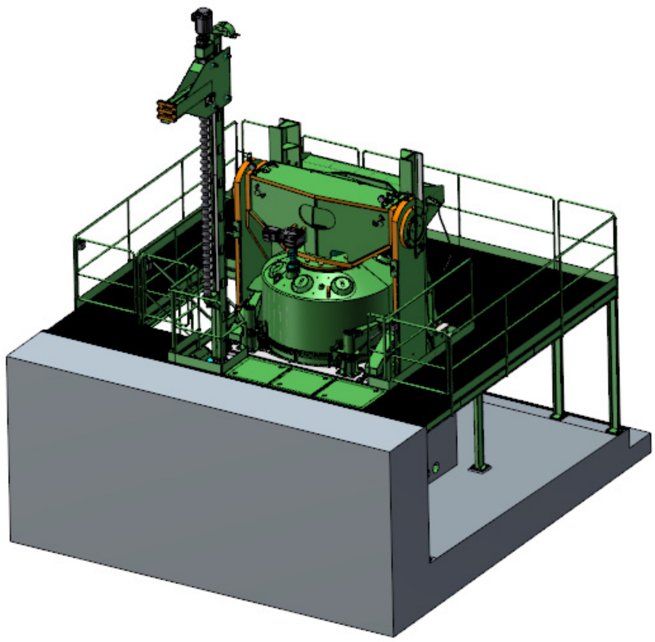


Fig. 3. 3D PDF of the whole curing press

COLOR		RGB	DESCRIPTION	EXAMPLE
GREEN		(90,190,90)	Unmachined surfaces	
AZURE		(10,255,255)	Machined surfaces (lathe, milling machine)	
ORANGE		(250,140,0)	Cut surfaces (water jet, saw, shears...)	
RED		(255,0,0)	Drilled surfaces	
WHITE		(255,255,240)	Grooves	
YELLOW		(255,255,130)	Standard connection parts (screw, nut, pin...)	
GREY		(120,120,130)	Purchased parts	

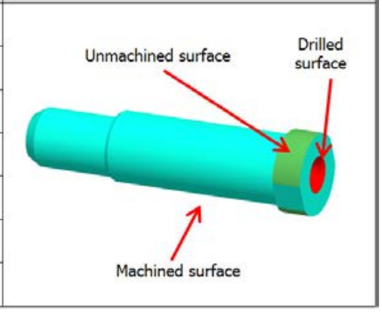


Fig. 4. Colouring according to machining technology

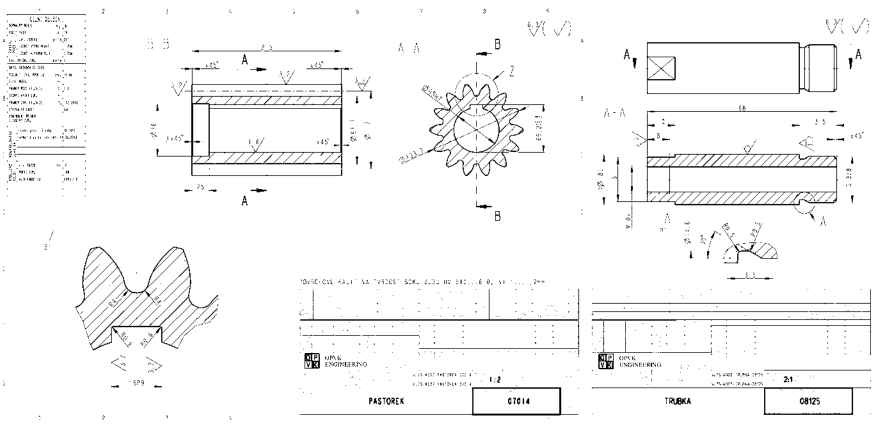
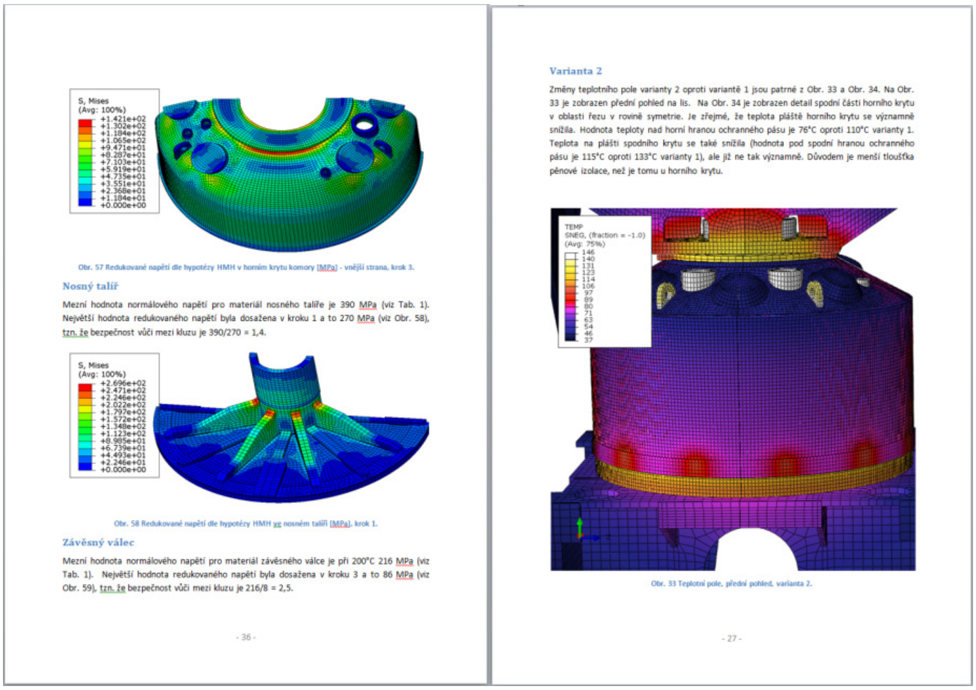


Fig. 5. Sample of the technical drawings



Obr. 57 Redukované napětí dle hypotézy HMH v horním krytu komory [MPa] - vnější strana, krok 3.

Nosný talíř

Mezní hodnota normálového napětí pro materiál nosného talíře je 390 MPa (viz Tab. 1). Největší hodnota redukovaného napětí byla dosažena v kroku 1 a to 270 MPa (viz Obr. 58), tzn. že bezpečnost vůči mezi kluzu je 390/270 = 1,4.

Obr. 58 Redukované napětí dle hypotézy HMH ve nosném talíři [MPa], krok 1.

Závěsný válec

Mezní hodnota normálového napětí pro materiál závěsného válce je při 200°C 216 MPa (viz Tab. 1). Největší hodnota redukovaného napětí byla dosažena v kroku 3 a to 86 MPa (viz Obr. 59), tzn. že bezpečnost vůči mezi kluzu je 216/8 = 2,5.

- 36 -

Varianta 2

Změny teplotního pole varianty 2 oproti variantě 1 jsou patrné z Obr. 33 a Obr. 34. Na Obr. 33 je zobrazen přední pohled na lis. Na Obr. 34 je zobrazen detail spodní části horního krytu v oblasti řezu v rovině symetrie. Je zřejmé, že teplota pláště horního krytu se významně snížila. Hodnota teploty nad horní hranou ochranného pásu je 76°C oproti 110°C varianty 1. Teplota na plášti spodního krytu se také snížila (hodnota pod spodní hranou ochranného pásu je 115°C oproti 133°C varianty 1), ale již ne tak významně. Důvodem je menší tloušťka pěnové izolace, než je tomu u horního krytu.

Obr. 33 Teplotní pole, přední pohled, varianta 2.

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Fig. 6. Sample of FEM calculations

5. Contribution of the developed study materials

- Transfer of knowledge and practical experience from engineering practice into university study materials.
- High complexity of the study materials.
- The study materials have been developed in accordance with the current knowledge in the field of engineering using modern methods.
- Increasing the attractiveness of technical fields to attract more students thanks to high-quality learning materials and modern methods of teaching.
- Possibility to create tasks for the term design projects based on some parts of the machines (e.g. the task could be to modify or enhance the certain part of the machine).

To illustrate the extent of the project of the curing press there are approximate numbers of pages:

- 600 drawings (manufacturing, assembly, parts lists, format A4 - A0)
- 250 pages of analytical calculations
- 77 pages of FEM calculation reports
- 25 interactive 3D PDFs
- 200 pages of descriptive and informative parts

6. Conclusion

The main purpose of this paper is to introduce the form and the structure of the newly developed study materials. These study materials have been designed in accordance with the requirements applicable to university education in mechanical engineering field. These requirements have been identified in this paper.

The primary reason for creating these study materials was the lack of practice-oriented study materials at mechanical engineering oriented universities in the Czech Republic. Thanks to the cooperation between academics and machinery companies it was possible to transfer practice skills and know-how into the study materials. The advantage of these study materials is their high complexity. They are not only excerpts of context which could be difficult for students to classify. These materials are the complete machine documentation beginning with the tender dossier and ending with the technical drawings.

The further optimization of the study materials will depend on the evaluation performed by students in the system for evaluating the quality of teaching at the University of West Bohemia in Pilsen or on individual responses of students conveyed to the teachers.

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